A Study of Ship Structural Dynamic Responses Subject Bulk Cavitation and High-Speed Jet Induced by Underwater Explosion

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ABSTRACT

Underwater explosion usually has two stages, including shock wave and bubble pulse. When shock wave and free surface interact, this will produce bulk cavitation. During the bubble pulse stage, the bubble will experience expansion and contraction in the collapse phase of bubble, a high-speed jet is produced. Bulk cavitation and high-speed jet may cause serious damage for ship structure. So this paper presents a study about the effect of bulk cavitation and high-speed jet on structures in an underwater explosion. To investigate the such problems mentioned above, the Finite Element Method (FEM) was applied. The Couple Eulerain-Lagrangian technique embed in ABAQUS software was used to solve the ship structural dynamic responses subject bulk cavitation and high-speed jet induced by underwater explosion in simulation. Furthermore, in this present paper, the response of a plate due to the shock wave induced by underwater explosion was also studied and verified by experimental study of Ramajeyathilagam & Vendhan[35]. For studying the effects of bulk cavitation and high-speed jet, a ship model was used as the object of study. The numerical result in this study may provide same helpful informations for the shipdesign work.

Keywords : underwater explosion、bulk cavitation、high-speed jet

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REFERENCES

[1] http://pl.wikipedia.org/wiki/Plik:USS_Mesa_Verde_(LPD-19)_during_shock_trials_-_080816-N-6031Q-213.jpg [2]Shin, Y.S.,“ Naval Ship-Shock Design and Analysis ”, Course Notes for Underwater Shock Analysis, Naval Postgraduate School, Monterey, CA, 1996.
[3] http://www.martec.com/popups/underwater-exp_popup1.html [4]Smith P. D., Hetherington J. G.,“ Blast and Ballistic Loading of Structure ”, pp.24-114(1994).
[5]A.M. Zhang, X.L. Yao, J. Li,“ The interaction of an underwater explosion bubble and an elastic-plastic structure ”, Applied Ocean Research, Vol. 30, pp159-171(2008).
[6] http://frietzak.net/kvdt/buitenland/cheonan-tot-zinken-gebracht-door-noord-koreaanse-torpedo/ [7]Driels, M.R.,“ The Effect of a Non-zero Cavitation Tension on the Damage Sustained by a Target Plate Subject to an Underwater Explosion ”, Journal of Sound and Vibration, 1980, Vol.73, No.4, pp.533-545.
[8]Reid, Warren D.,“ The Response of Surface Ship to Underwater Explosion ”, Aeronautical and Maritime Research Laboratory, 1996, DSTO-GD-0109.
[9]Wood, Steven L.,“ Cavitation Effects on a Ship-Like Box Structure Subjected to an Underwater Explosion ”, Master Thesis, Naval Postgraduate School, 1998, Monterey, California.
[10]T.G. Liu, B.C. Khoo, K.S. Yeo,“ The simulation of compressible multi-medium flow II. Applications to 2D underwater shock refraction ”, Computers & Fluids, 2001, 30, 315-337.
[11]Schneider, Nathan A.,“ Prediction of Surface Ship Response to Severe Underwater Shock Explosions Using a Virtual Underwater Shock Environment ”, Master Thesis, Naval Postgraduate School, 2003, Monterey, California.
[12]Didoszak, Jarema M.,“ Parametric Studies of DDG-81 Ship Shock Trial Simulations ”, Master Thesis, Naval Postgraduate School, 2004, Monterey, California.
[13]Young S., Shin,“ Ship shock modeling and simulation for far-field underwater explosion ”, Computers and Structures, 2004, 82, 2211-2219.
[14]Sprague, Michael A., Geers, Thomas L.,“ A spectral-element / finite-element analysis of a ship-like structure subjected to an underwater explosion ”, Computer Methods in Applied Mechanics Engineering, 2006, 195, 2149-2167.
[15]Gong, S. W., Lam, K.Y.,“ On attenuation of floating structure response to underwater shock ”, International Journal of Impact Engineering, 2006, 32, 1857-1877.
[16]Xie, W. F., Liu, T. G., Khoo, B. C.,“ The simulation of cavitating flows induced by underwater shock and free surface interaction ”, Applied Numerical Mathematics, 2007, 57, 734-745.
[17]梁卓中，林世麒，“爆震引至之空蝕研究”，大葉大學機械與自動化學系碩士學位論文， 2008。
[18]M.S. Plesset and R.B. Chapman,“ Collapse of an initially spherical vapor cavity in the neighborhood of a solid boundary ”, Division of engineering and applied science, California Institute of Technology, Pasadena, California(1970).

[19]J.R. Blake and R.P. Tong,“ Jet impact in Collapsing bubbles ”, 12th Australasion Fluid Mechanics Coference, The University of Sydney, Australia, pp819-822(1995).
[20]Y.L. Zhang, K.S. Yeo, B.C. Khoo and C. Wang,“ 3D jet impact and toroidal bubbles ”, Journal of computational physics, pp336-360(2001).
[21]Q.X. Wang, K.S. Yeo, B.C. Khoo and K.Y. Lam,“ Vortex ring modeling of toroidal bubbles ”, Theor. Comput. Fluid Dyn, pp1-15(2005).
[22]C. Wang, B.C. Khoo, K.S. Yeo,“ Elastic mesh technique for 3D BIM simulation with an application to underwater explosion bubble dynamics ”, Computers & Fluids, pp1195-1212(2003).
[23]E. Klaseboer, B.C. Khoo and K.C. Hung,“ Dynamics of an oscillating bubble near a floating structure ”, Journal of Fluids and Structures, Vol. 21, pp395-412(2005).
[24]A.A. Korobkin, T.I. Khabakhpasheva, G.X. Wu,“ Coupled hydrodynamic and structural analysis of compressible jet impact onto elastic panels ”, Journal of Fluids and Structures, Vol. 24, pp1021-1041(2008).
[25]梁卓中、鄧作樑、戴毓修，“水屏彈爆炸對艦體安全之影響研究及資料蒐集彙整”，國推會成果報告，NSC-90-2623-7-212-005(2001)。
[26]愛發股份有限公司，”ABAQUS實務入門指導”，全華科技圖書股份有限公司，2005.
[27]ABAQUS Theory Manual, Version 6.11.1, Hibbit, Karlsson, and Sorensen, Inc., Pawtucket, RI (2011).
[28]ABAQUS User’s Manual, Version 6.11.1, Hibbit, Karlsson, and Sorensen, Inc., Pawtucket, RI (2011).
[29]I. Smojver,“ Bird strike damage analysis in airraft structures using Abaqus/Explicit and coupled Eulerian Lagrangian approach ”, Composites Science and Technology, 71, 2001, 489-498.
[30]Benson DJ, Okazava S.,“ Contact in a multi-material Eulerian finite element formulation ”, Comput Methods Appl Mech Eng 2004;193:4277-98.
[31]Wilbeck JS.,“ Impact behavior of low strength projectiles ”, Air Force Materials Laboratory, Technical Report AFML-TR-77-134; 1977.
[32]Chizari M, Barrett LM, Al-Hassani STS. An explicit numerical modelling of the water jet tube forming. Comput Mater Sci 2009；45:378-84.
[33]Costanzo, F.A. and Gordon, J.D.,“ An Analysis of Bulk Cavitation in Deep Water ”, DTNSRDC, UERD Report, May 1980.
[34]MATLAB, R2008a, The MathWork, Inc., 2008.
[35]K. Ramajeyathilagam, C.P. Vendhan,“ Deformation and rupture of thin rectangular plates subjected to underwater shock ”, International Journal of Impact Engineering, 2004, 30, 699-719.
[36]Arons A.B., et al,“ Long Rang Shock Propagation in Underwater Explosion Phenomena II ”, Underwater Explosion Compendium, Vol. 1(1949).